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A Preliminary Report Concerning the Causes of the Low Fertility of Trout Eggs at the Jonkershoek Trout Hatchery

by

D. HEY, M.Sc.

NASIONALE PERS, BEPERK, Capetown.
1939.

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INTRODUCTION.

The problem in question is a very wide one and can be considered from so many angles, that in order to arrive at any conclusive results investigations would have to be carried out over a number of years. The factors to be considered are so manifold that the present investigation can only be used as an introduction, from which basis future specific research may be carried out. The solution to the problem is not only of theoretic interest but is also of economic importance, as approximately half of the eggs stripped each year are lost through initial infertility.

For convenience the preliminary investigation has been carried out under the following headings: A. Stripping Technique; B. The Male; C. The Female; D. Climatic Conditions. It is however realised that an inter-relationship between two or more sections, may, and most probably does exist.

OWN INVESTIGATIONS.

SECTION A. STRIPPING TECHNIQUE.

In the past the method of stripping and fertilizing the eggs at the Jonkershoek Hatchery has been as follows. Two hens are placed on the stripping table and allowed to exhaust themselves. One of them is then grasped tightly above the tail with the left hand in such a manner that the arch between the thumb and first finger closes tightly over the back. The right hand is placed above the shoulder and by gripping gently and bending the fish back slightly the eggs flow into the stripping basin if the fish is ripe. In this way the hens are stripped, as many eggs being taken as the fish will yield without undue pressure. By holding a cock fish in the same way and exerting a little pressure about half way down the abdomen with the forefinger, the milt will flow freely. A little water is then added, the

contents of the basin are stirred and transfered to a larger basin containing water. Here they are left undisturbed until the eggs separate (i.e. lose their power of adhesion). They are then thoroughly washed to remove all dead milt and placed on glass grilles in the hatching house. The eggs are examined twice a day and the dead ones picked out. After approximately twenty one days in the case of the Brown and fourteen in the case of the Rainbow trout, the embryo is clearly visible in the egg and at this stage the eggs are washed under a strong stream of water; those which are infertile, or in which segmentation has not proceeded very far then turn white. (Exosmosis takes place.) These are then removed and the remaining eggs are placed in a shallow white dish of water in strong light. In this way all the eggs containing weakly developed embryos can be picked out. Although it was realised that the fertility of eggs at the Hatchery was low, no statistics are available. In order to form an idea of the efficacy of this method in the case of Brown trout, seventeen batches of eggs, varying in size from 124 to 2195 eggs, were treated at intervals through the season. They yielded an average percentage fertility of 49.8, individual batches varying between 80.1 and 0 per cent. Similarly the Rainbow trout gave an average gross fertility of 63.8 per cent, individual batches varying between 98.3 and 0 per cent. As these results are very poor, a set of experiments was conducted in an attempt to improve the technique of fertilization as employed in Jonkershoek.

Experiment 1.

To investigate the effect of simultaneous stripping and milting. Using the technique already described, a ripe hen and a ripe cock were stripped into 50 c.c. of water in the stripping basin, simultaneously. The contents of the basin were allowed to stand for three minutes, when the eggs were transferred to a larger basin with water and allowed to separate. Three batches of eggs were treated with a resulting average percentage fertility of 50.4.

Experiment 2.

As a variation of the above, a hen was stripped into 50 c.c. of water and the eggs milted. Thereafter the procedure was as

has already been described. Five batches of eggs gave an average percentage fertility of 64.2.

Experiment 3.

A suspension of milt in water was made by milting a cock into 40 c.c. of water. Into this suspension a hen was then stripped and the eggs treated as before. The average percentage fertility of five batches of eggs was 24.3.

The above experiments are variations of the old "wet" method of impregnation (i.e. bringing the eggs and milt into contact in the presence of water). In opposition to this method, we have the "dry" method, discovered as far back as 1856 by Vrasski in Russia. Concerning the relative merits of these two processes, Smolian (1920) states: "Bei der alteren 'nassen' Methode kamen deshalb nur etwa 20% der Eier zur Befruchtung (wie es in der freien Natuur geschieht), während bei der trockenen Methode eine Befruchtung bis zu 98% aller Eier garantiert werden kann". The dry method as employed at the Hatchery in Ceylon (1935) was next attempted.

Experiment 4.

A hen was stripped, as many eggs as possible being taken without undue pressure. Milt from a cock fish was then expressed over the eggs using as much milt as possible. Instead of stripping a number of fish into the same basin as is the practice in Ceylon, they were taken singly as it was found that a number of hens produced totally infertile eggs. In this way these fish could be identified and tagged for further examination. The contents of the basin were then left undisturbed for five minutes, whereupon clean water was poured over the eggs to wash them free of milt. They were then placed in a large basin of clean water and stirred at intervals until they separated when they were placed in the hatching house. Ten batches of eggs (varying from 105 to 326) were treated and gave an average percentage fertility of 83.5, individual batches varying between 94.6 and 67.4. This method, then, seems to show an improvement on the older method already described; but in order to substantiate or disprove this, the experiment was repeated the following season (1938). This time, however, the test was made more intensive and a control by the old method was taken in each

case. Twelve batches were treated by the test method giving an average percentage fertility of 89.4, individual batches varying between 73.4 and 98.6 per cent. The control gave an average percentage fertility of 53.9, individual batches varying between 22.4 and 83.1 per cent. These results are an improvement on the old method but their inconsistency shows the need for further investigation.

The question now arises of whether or not the eggs are taken when they are properly ripe. Under natural conditions a hen runs up stream, chooses a suitable spot and commences making a redd. Therefore it seems reasonable to assume that any hen in the act of making redd is ripe.

Experiment 5.

A number of hens were placed in a pond fed by a long stony race suitable for spawning. Any hens running up stream and beginning to make nests were trapped and stripped by the standard method. Six hens came up to spawn and of the six two were far from ripe. The remainder gave an average percentage fertility of 51.1. These naturally run fish then, produce as poor results as fish taken in the ordinary way. Although this experiment does not disprove the fact that the eggs may be stripped before they are ripe, yet it shows that the solution to the problem of low fertility lies in some other direction.

If it is fair to rely on the results of two seasons' work, it is evident that an improvement in stripping technique has been effected by the application of a more suitable method. The results however are far from constant varying from 67 to 98 per cent fertility. This indicates that there are other factors involved and the solution to the problem, then, if such be possible depends on more than one factor.

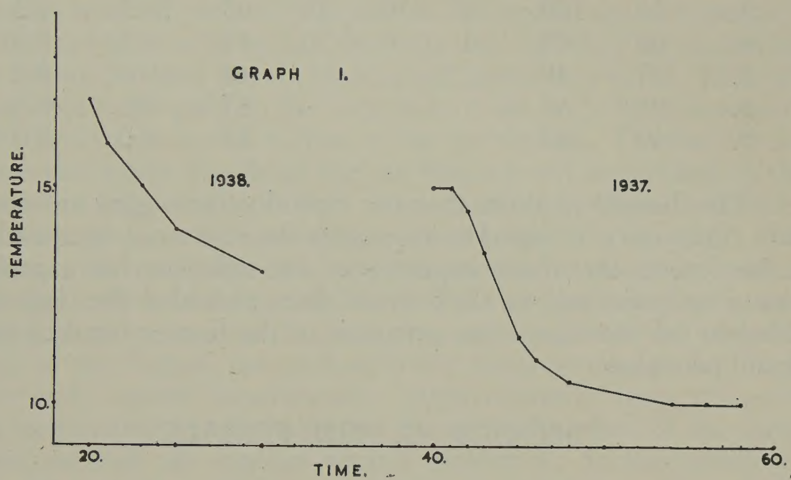
SECTION B. THE MALE.

The first step in the investigation was purely anatomical. Four specimens were dissected and in each case the genital system was found to be normal.

Experiment 1.

The quality of the milt was then examined microscopically. Using a sterilized needle a small quantity of milt was placed in

water of known temperature under the microscope and the average life of the sperms was timed in each case. The experiment was repeated in 1938. Judging from the results, above 10 C. the life of the milt does not exceed 60 seconds. The vitality of the milt is in inverse proportion to the temperature of the water. As can be seen, some of the males produced lifeless milt and the use of such fish in stripping would account for the total infertility of some batches of eggs. The results are represented graphically in Graph 1, where the vitality of the milt in seconds



is plotted against the temperature in degrees Centigrade. The graphs are rough curves, thus illustrating the fact that the vitality of the milt decreases as the temperature rises. Unluckily the pH value was not known when the 1937 readings were taken, but it is surmised that the discrepancy between the '37 and '38 results is due to the low pH of 6.5 when the latter readings were taken.

Experiment 2.

These findings were then tested practically. A suspension was made from the milt of 4 males in 250 c.c. of water. As the milt was added to the water a stop watch was set going. This suspension was then added to seven batches of eggs as follows. A number of eggs constituting Batch 1 were expressed into a bowl and approximately 50 c.c. of the milt water suspension was added as soon as possible, the time being noted. (The reading

on the watch gives the time during which the sperms have been in contact with water, i.e. active.) Similarly a further 6 batches were dealt with, the time in each case being noted. (Vide Table I.)

TABLE I.

Batch.	Time.	No.	W.D.	Def.	Inf.	D.	%F.	%W.D.
1.	23	52	31	0	7	14	59.6	59.6
2.	41	76	37	1	11	27	50.	48.7
3.	55	150	2	30	23	95	21.3	1.3
4.	60	65	1	0	20	44	1.5	0.0
5.	77	48				48	0.0	0.0
6.	95	65				65	0.0	0.0
7.	110	83				83	0.0	0.0

The dissections show that the reproductive organs are normal. Although it is hoped to investigate the milt more intensively in the future, the above experiments are sufficient for a preliminary examination, as they show that, provided the milt is added to the ova soon after extrusion of the former fertilization should take place.

SECTION C. THE FEMALE.

According to Gegenbaur (1879), Günther (1880), Owen (1866) and Sedgewick (1905), the ova of the Salmonidae are dehisced into the body cavity and evacuated through the abdominal pore. With reference to all these authorities Kendall (1921) states:— "The prolongation backwards of the mesovarium and ovarian investments form the oviducts, which in the Salmonidae and Coregonidae, are troughlike, open above, the inner wall consisting of the mesovarium and the free outer wall supported by the abdominal wall. Near the outlet the two troughs unite into one above the intestine at the point of termination of the dorsal mesentery. At a short distance from the genital orifice each outer wall of the common channel is deflected and is attached to the respective wall of the abdomen." Van den Broek (1933) who has done the latest work on the subject states:—"Die niedrigere Stufe, bei welcher ein besonderer Ausführungsgang noch nicht existiert, und die frei in die Bauchhöhle fallenden Eier durch einen Porus abdominalis nach aussen entleert

werden, wird durch die Aale und Salmoniden repräsentiert." A number of apparently healthy hatchery fish were dissected but in no two cases was the condition of the ovaries or the relationship of the mesenteries the same. Material was then obtained from further afield. Two Brown Trout hens measuring 25 and 33 cm. respectively, from the Berg river and two specimens 35 and 38 cm. respectively from the Steenbras reservoir were then dissected. The description given below is based on these four dissections. The ovaries are elongated, roughly triangular tapering bodies, situated one on either side of the median dorsal mesentery. Their outer faces lie against the body wall and they are suspended at a level between the air bladder and alimentary canal. They are suspended obliquely to the long axis of the body by a mesentery attached to the mesial surface of the air bladder. This membrane runs the entire length of the air bladder and terminates at the posterior edge of the median dorsal mesentery. This suspensory mesentery does not extend the whole length of the ovary, thus leaving the posterior end free. Extending between the median ventral surface of the air bladder and the median dorsal surface of the alimentary canal and terminating at a level with the posterior end of the former, the median dorsal mesentery serves to divide the body cavity incompletely. Approximately from its point of termination, to the anus, on the ventral surface of the intestine, extends the median ventral mesentery. In the middle of the body it is absent, but exists in the anterior region as the falciform ligament. The ovary is completely enclosed in an ovarian membrane which is stouter on the inner than the outer surface. The ovary consists of numerous transverse septa fed by fine capillaries. The eggs lie in irregular rows between the septa and in addition each egg is enclosed in a follicle. As the eggs ripen they become larger thus distending the ovary, until the ovarian membrane ruptures, the split commencing in the middle line on the outer posterior surface, the eggs being shed into the body cavity. There appears to be no sign of a functional oviduct or ovarian groove although rudiments of such in some form or other may exist. The mesenteries are thin and delicate with the result that in a fish which has spawned, their relationships are somewhat obscure. Just behind the anus lies the genital opening at the point of the genital papilla. As soon as pressure is applied to the abdomen (if the fish is ripe) this papilla everts forming a funnel which serves for the outward passage of the eggs (Fig. 1.)

A number of Hatchery stock fish were dissected and in each case the body cavity was congested with, or contained old eggs and egg shells. A description of one of these will have to serve as an illustration.

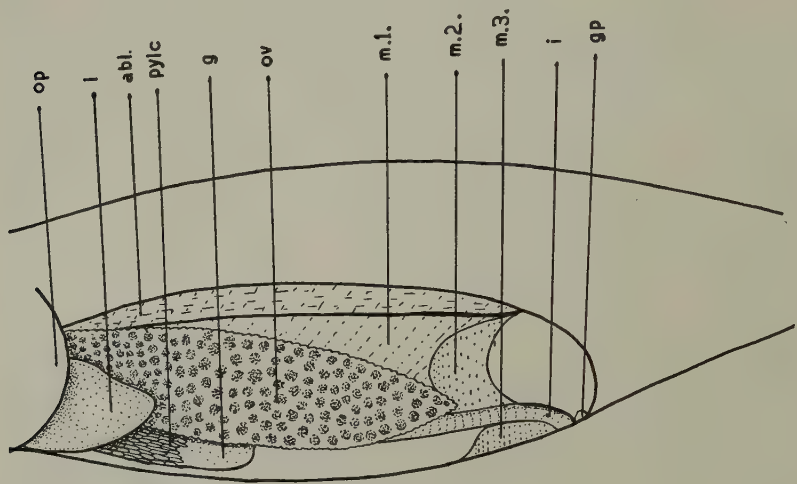


FIGURE 1.

abl, air bladder; g, gut; gp, genital papilla; i, intestine; l, liver; m.l., mesentery suspending the ovary; m.2., median dorsal mesentery; m.3., median ventral mesentery; op, operculum; ov, ovary; pylc, pyloric caceca.

Case 4. Brown Trout hen, 30.5 cm. Condition Fair. 14/2/38.

Although the spawning season had ended six months previously and it was still three months short of the 1938 season, the left side of the body cavity was packed with eggs of three different ages. (1) Empty and half decomposed egg shells. (2) Large bright yellow eggs in a flaccid state. (3) Small clusters of tiny scarlet eggs in an undeveloped state. The old shells were interpreted as the remains of the '36 season's eggs, the flaccid yellow eggs as the '37 season's and the small eggs as the developing ova for the '38 season. The right side of the body cavity was entirely free of dead shells and eggs. The ovary was entire and completely enclosed by mesentery. It contained however, a very heterogeneous collection of eggs, varying from fully developed, to eggs no larger than the head of a small pin. (Figs. 2 and 3.)

The majority of mature and degenerating eggs remaining in the body cavity contained a peculiar white spot lying in or on the yolk. The cause and nature of this is unknown, but a number of facts were ascertained from the preliminary exami-

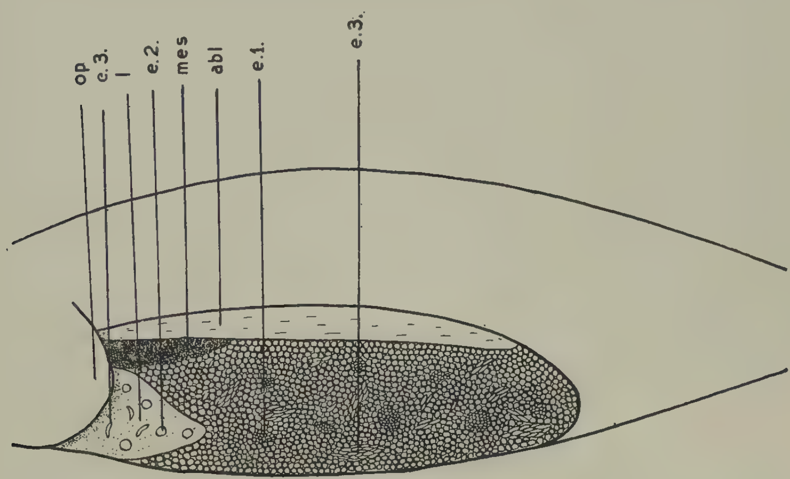


FIGURE 2.
e.1., undeveloped eggs; e.2., fully developed eggs; e.3., degenerating egg shells; mes, mesovarium. Other abbreviations as in Figure 1.

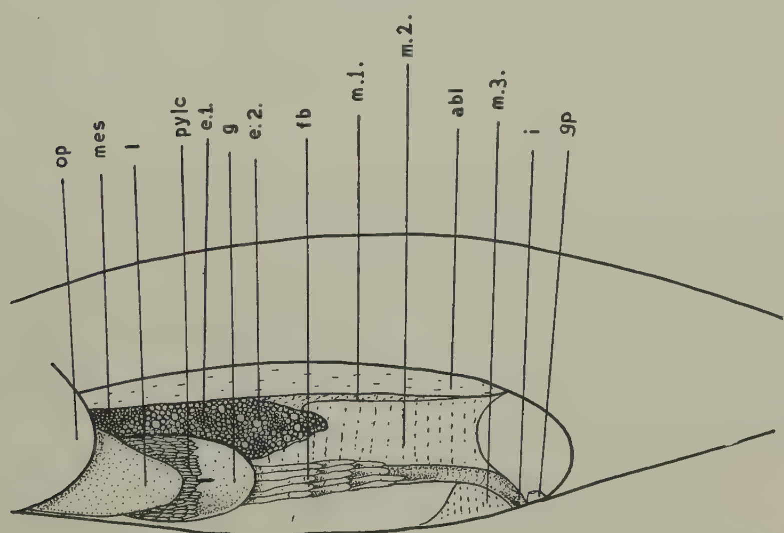


FIGURE 3.
fb, fat bodies. Other abbreviations as in the previous figures.

nation. All eggs showing any trace of white spot are infertile. White spot seems to be confined chiefly to the older fish. When the eggs are in this condition a large quantity of ovarian fluid is produced which coagulates in water. A similar curdling effect is produced by bursting a normal egg under water. As soon as white spot eggs are placed in water they turn white, thus showing that they are unable to control the osmotic processes. In order to ascertain whether or not white spot was a permanent disease, eight fish having eggs in this condition in 1937 were tagged for examination the following season. Of these only two survived. They were stripped early in the '38 season and yielded a percentage fertility of 77.5 and 83.9. This result suggests that white spot is merely a condition or disease of the eggs themselves. It is not a permanent disease of the fish or ovaries. The solution to the problem then, if such be possible, must be sought from a study of the eggs themselves although it is likely that they are affected by the condition of the parent fish.

As as result of the 1937 season's investigations it appeared that abnormalities were far more prevalent among the older than the younger fish. For experimental purposes 7 young hens (2-3 years) were set aside at the end of the '37 season and were fell fed. They were stripped the following season and gave a gross fertility of 96.6 per cent, individual fertilities varying between 92.5 and 100 per cent. These results are entirely satisfactory and it seems as if a stock of young fish should be kept.

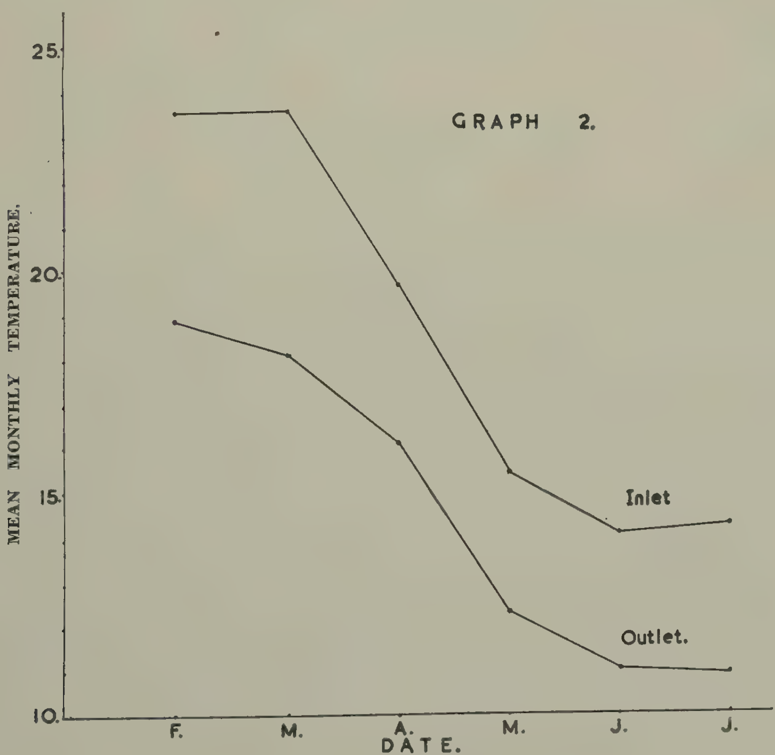
Until the subject has been investigated more fully, no conclusions can be drawn. Two aspects, however, stand out clearly as a result of the preliminary investigation: (1) There is something radically wrong with the older female stock fish. (2) The solution to the problem of raising the fertility of the eggs seems to be the building up of a stock of young healthy fish to be used over two or three seasons only. Admittedly, a larger number of stock fish would have to be kept to maintain the total output of eggs, but this would be compensated for, by the elimination of losses due to initial infertility.

SECTION D. CLIMATE.

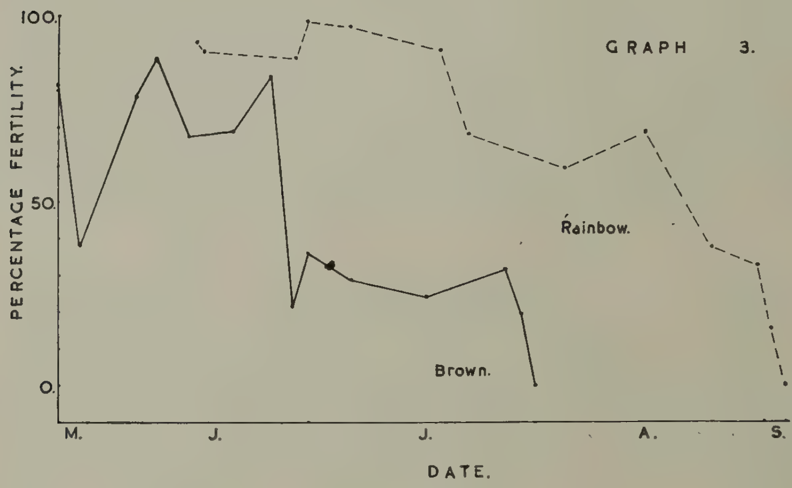
To obtain an idea of the climatic conditions in Jonkershoek records of temperature and acidity of the water were kept. The

streamflow, rainfall and air temperature records were obtained through the courtesy of the Forest Research Officer, Jonkershoek.

Temperature. By means of a Sixs maximum and minimum thermometer placed in the stream feeding the pond in which the stock fish were kept, a daily record of the temperature was obtained. Although no temperatures are on record for January which is usually the hottest month, a glance at the graph will show how high the temperature rises at times. According to the experiments of Embody (1921) 30° C is the highest temperature at which trout could live. The Jonkershoek Temperatures are not as high as the figures given by Embody (op. cit.), yet during March 1938 27° C was recorded twice, and temperatures of 24° C and over were not infrequent. Although this temperature may not actually endanger the life of the fish, yet eventually it is bound to affect its vitality. (Graph 2.)



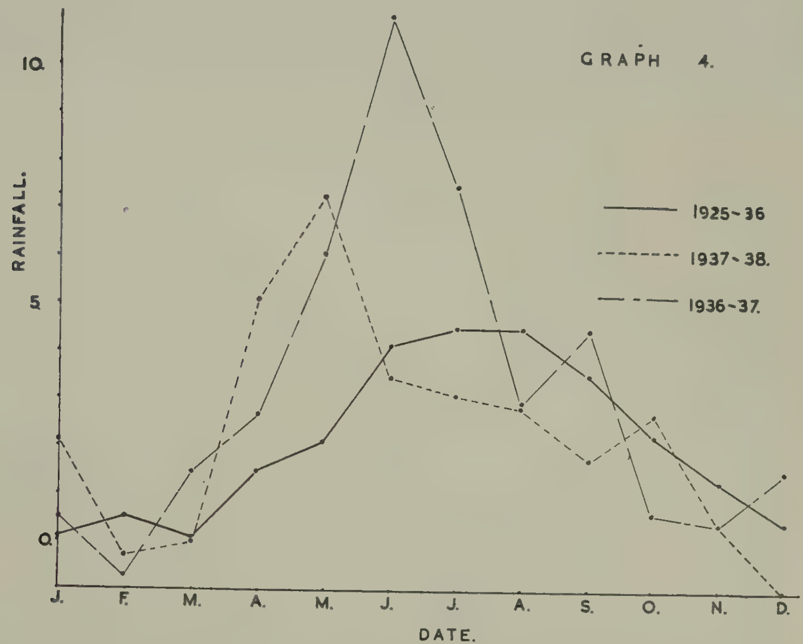
According to the results of Embody (op. cit.) and the statements of Smolian (op. cit.) the Rainbow can withstand higher temperatures than the Brown trout. In order to compare the percentage fertility of Rainbow and Brown trout, batches of eggs were taken from each at intervals during the spawning season. These batches were all treated in the same way and as they hatched, the percentage fertility in each case was calculated. The result was then plotted against the date as shown in Graph 3. An analysis of the graph shows: (1) That



the average percentage fertility of the Rainbows is higher than the Browns. (2) That the Rainbow comes on to spawn later than the Brown trout, and that spawning in the case of the former is extended over a longer period. (3) The percentage fertility in both cases drops as the season extends. Based on these statistics it seems that Rainbow trout are better suited to the Jonkershoek conditions than the Brown.

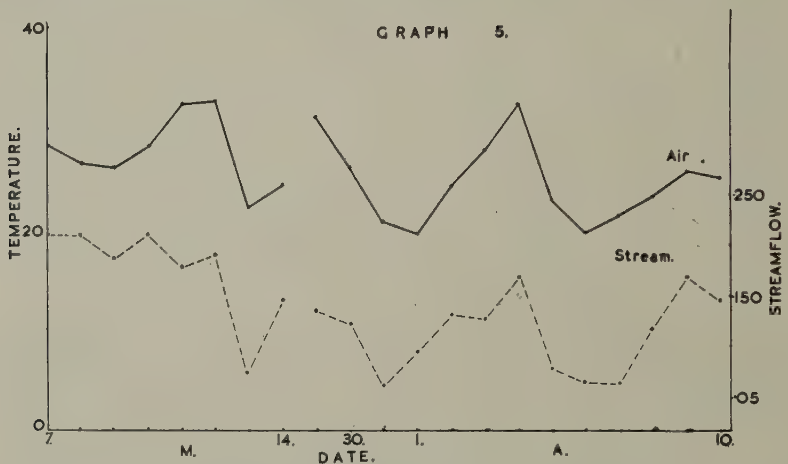
Rainfall. The gauge on which the readings were taken is situated in the middle of the catchment area and thus gives a fairly good idea of the rain falling in that locality. The results are represented in Graph 4 and show the monthly rainfall during the 1937 and 1938 seasons as compared with the mean monthly rainfall during the previous twelve years. An analysis of the data shows that the greater portion of the rain falls between

April and September. Thus during the hot summer months very little rain falls, the streamflow drops and the water temperature rises.



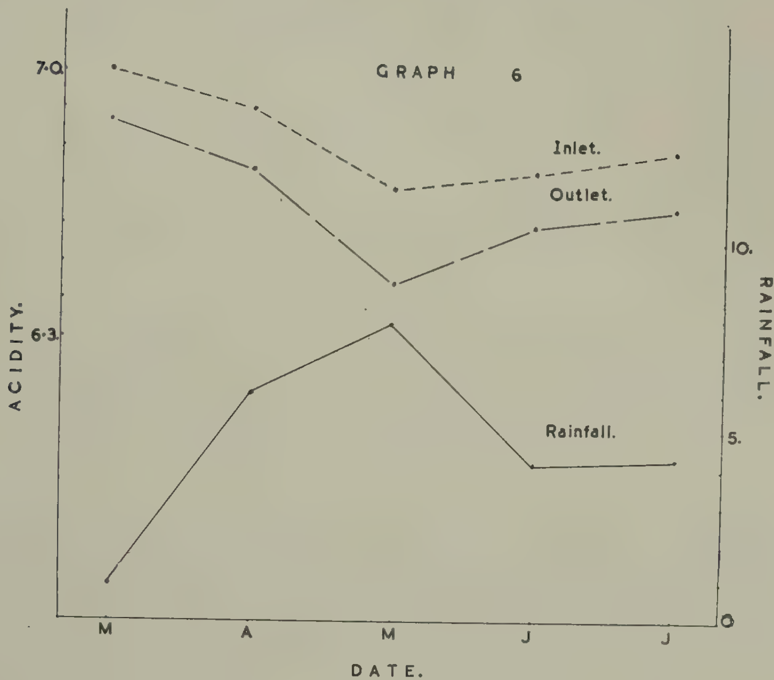
Streamflow. The charts from the water level recorder in the stream which feeds the Hatchery show a 24 hour fluctuation which is especially noticeable in the summer months and is apparently associated with hot weather. This may be due to one of three causes or a combination thereof. (1) The effect of the direct evaporation of water. (2) Transpiration of plants in the stream bed. (3) The effect of temperature on the recorder. In order to establish the fact that actual fluctuation in streamflow does occur, check readings of the water level were taken with a Hook gauge. These readings support the hypothesis that the fluctuation is due to real changes in streamflow. As transpiration is also effected by temperature, and if the fluctuation is associated with hot weather, a correlation between daily temperature and fluctuation in streamflow should exist. We cannot, however, expect this correlation to be very close as other factors such as wind, cloudiness, etc., would also effect the streamflow. In Graph 5, the maximum daily temperature was

plotted against the daily fluctuation in streamflow over two different periods. As can be seen a fair correlation exists. On hot summer days, the fall in streamflow is often over 25 per cent. and on occasions may amount to 40 per cent. This means an actual drop in flow of .169 cu/secs, which from a maximum flow of .426 cu/secs, leaves only .257 cu/secs. Furthermore this drop in flow occurs concurrently with the maximum temperature.



Acidity of the Water. All the pH readings were taken with a Lovibond Comparitor. (1) In order to test the reliability of the method and technique of determination of the pH, 40 consecutive water samples were taken at inlet and outlet alternately. The determinations showed no variation and it may therefore be assumed that all other pH determinations are reliable to a high degree. (2) There is a difference in pH between the inlet and the outlet (i.e. where the water enters the hatchery and where it leaves). By applying Students test (1936) of the significance of paired differences, it can be shown that the odds are overwhelmingly strong against the difference being due to chance. Therefore there is a rise in the acidity of the water during the period that it is circulating through the ponds. In Graph 6, the mean monthly pH at inlet, and outlet was plotted against the rainfall. The graph illustrates the fact that there is an appreciable difference in pH. Secondly, the wetter the month the more acid does the water become. This may be due to the larger amount of Carbon

Dioxide given off by the plants during the cloudy weather. As can be seen the Jonkershoek water is acid. Southern (1932), who has investigated fish life in acid waters states "Acid waters produce small, early maturing, short lived trout". That the Jonkershoek trout mature early there is no doubt and the acidity of the water may therefore be yet another contributing factor to the deterioration of the ova in the older fish.



FINAL CONCLUSIONS.

As a result of the preliminary examination I tentatively submit the following hypothesis to be proved or disproved by subsequent work. It is best explained by the aid of a hypothetical, purely diagrammatic graph. (Vide Fig. 4). By plotting the percentage potential fertility (i.e. the precentage of eggs which would produce embryos upon fertilization) of the same hen over a period we would expect to obtain a curve of the type shown, although the actual shape can only be surmised at. For

descriptive convenience the curve has been divided into four periods. Starting at x, with the immature ova, we have growth and development taking place. As the eggs do not all develop at the same rate a time will come when a few eggs ripen. From then on the remaining eggs will ripen off very quickly and the curve will rise rapidly until it enters period B. Period A may be regarded as a period of infertility due to **unripeness.**

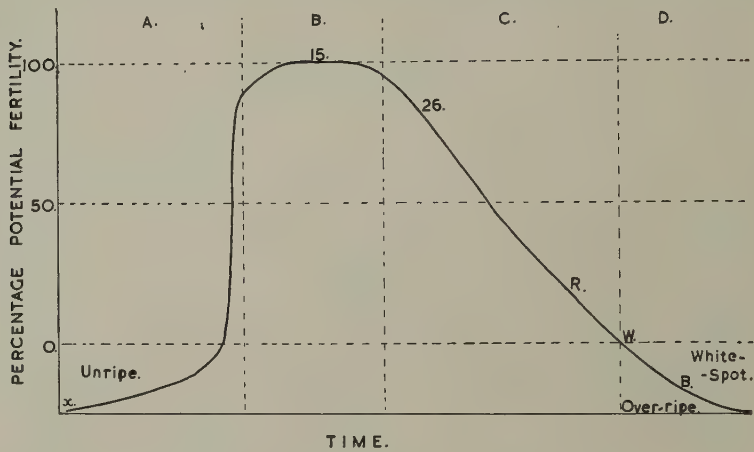


FIG. 4.

Period B is regarded as a period of optimum fertility and it is assumed that under natural conditions the fish would spawn at this time should climatic conditions be favourable. It is at this time that stripping should take place. As a result of the experiments cited below it seems that this period is a very short one in Jonkershoek, due most probably, to the warm climate. There is no natural stimulus to cause the fish to spawn as we have a succession of bright sunny days with a fairly high water temperature. This period is in all probability inversely proportional to the temperature, the lower the temperature the longer the eggs retain their potential fertility and vice-versa. Passing now to period C we enter a phase of decline the eggs as it were gradually dying off. Towards the latter quarter of the period the eggs have declined so far that they yield a very poor percentage fertility and the majority of eggs fertilized produce weakly developed embryos. In period D the eggs are totally infertile due to **overripeness,** and as they become older they begin to decompose. In my opinion white spot is

the first visible sign of this decomposition. The eggs then become flaccid the body cavity gradually fills with "Leibeshöhlenflüssigkeit", and decomposition gradually continues until only the empty shells are left in the body cavity. This hypothesis is based on a number of observations and experiments cited below.

1. White spot is, in the majority of cases confined to the latter weeks of the spawning season. The final batches of eggs taken every season invariably have white spot.

2. As stated above, the tagging experiment showed that white spot does not occur permanently in a fish.

3. A second stripping from the same fish invariably yields poorer results, never better, than the best thus indicating that the percentage fertility is dropping off.

4. When only a few eggs of a batch show white spot, the remainder will also be infertile although they appear perfectly normal. Explained by the above hypothesis this means that all the eggs are overripe, some however have degenerated a little further than the rest, the decomposition having become visible to the naked eye as a small white spot.

5. When the ovarian fluid from a hen effected by white spot is added to water a white precipitate is produced, thus indicating that this fluid contains the contents of decomposing eggs.

6. When placed in water white spot eggs turn white.

7. To investigate whether or not degeneration of the eggs does take place with age, three large hens, apparently ripe, were marked with red, white and blue tags respectively. For the sake of descriptive convenience, the batches of eggs obtained from these hens were designated by the letters R, W, B, respectively. The first small batch of eggs was taken from these hens on the 23rd of June and were milted by the usual dry method. Periodically eggs were taken from each of the hens, the results of which are recorded in Table 2. Subsequently a further two hens 15 and 26 were dealt with in the same way.

TABLE 2.

Batch	Date.	No.	W.D.	Def.	Inf.	D.	%F.	%W.D.
R.	23/6	29	2	3	4	20	17.2	6.9
R2.	27/6	62				62	0.	0.
R3.	1/7	78				78	0.	0.
R4.	4/7	102				102	0.	0.
R5.	8/7	Remaining eggs had white spot.						
W.	23/6	45				45	0.	0.
W2.	1/7	110				110	0.	0.
W3.	8/7	284				284	0.	0.
W4.	15/7	Remaining eggs had white spot.						
B.	23/6	45				45	0.	0.
B2.	27/6	54				54	0.	0.
B3.	1/7	Remaining eggs had white spot.						
B4.	12/7	Eggs flaccid and partly decomposed.						
B5.	5/8	Numbers of empty shells present.						
15.	16/6	120	118	2	0	0	100.	98.3
15.1	23/6	71	19	7	0	45	36.7	26.8
26.	16/7	179	147	8	10	14	86.5	82.0
26.1	23/7	75	45	5	12	13	66.6	60.0

An examination of the results shows that in the case of R we have a deterioration from a percentage fertility of 17.2 through stages of total infertility (where however the eggs appear perfectly normal to the naked eye) to the stage where the eggs show the so called white spot. Expressing this by means of the graph, the first batch of eggs would lie approximately at the point R, and from there the development would have followed the curve. Had eggs been taken a day after batch R, it is presumed that they would have yielded a percentage fertility lower than 17.2, but that they would not have been totally infertile. W would lie lower than R on the curve passing through total infertiliy to white spot. The same applies to B. B, however, was isolated for a further period to find out whether or not any further degeneration would take place in the eggs. By the 12th of July the eggs had become quite flaccid and on the 5th of August a number of egg shells were observed thus showing that the eggs were gradually decom-

posing. Case 15 was a young fish spawning for the first time and the first stripping produced 100 per cent fertile eggs thus showing that the fish had been stripped at the period of optimum fertility. (At the peak of the curve.) A second and final batch of eggs was taken a week later and yielded a percentage fertility of 36.7. This indicates that during the intervening week some of the eggs had become overripe and were thus no longer potentially fertile. Case 26 illustrates the same point. Here, however, the eggs had developed past the apex of the curve before the first batch was taken.

Another fact which supports the hypothesis is that the gross fertility in the case of both the Rainbow and Brown trout drops as the season extends. This is illustrated in Graph 3 in the section on Temperature. This drop in fertility is easily explained by the new hypothesis. As the season advances the hens tend to become overripe with the result that the eggs are no longer potentially fertile. If instead of stripping twice a week, the hens could be stripped more frequently it might prevent them from becoming overripe and at the same time have the advantage of condensing the stripping season.

LIST OF ABBREVIATIONS EMPLOYED FOR THE FIGURES.

abl — Air bladder.
e.1. — Undeveloped eggs.
e.2. — Fully developed eggs.
e.3. — Degenerating egg shells.
fb — Fat bodies surrounding intestine.
g — Gut.
gp — Genital papilla.
i — Intestine.
l — Liver.
m.1. — Mesentery suspending ovary.
m.2. — Median dorsal mesentery.
m.3. — Median ventral mesentery.
mes — Mesovarium.
op — Operculum.
ov — Ovary.
pylc — Pyloric caeca.

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